3GPP TSG-RAN WG1#9
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TSGR1#9(99)j51

Agenda Item:

Source: Samsung Electronics Co.

Title: Random Pattern for Gated DPCCH Transmission

Document for: discuss and approve

1. Introduction

In last WG1#7bis Kyongju meeting, a concern on the EMC effects of gated DPCCH transmission to the hearing aid apparatus has been raised. After that, a concept of random gating was introduced by Mitsubishi [1]. In WG1#8 New York meeting [2], a random gating pattern generation algorithm was proposed by Samsung, however, the algorithm was not approved at the meeting because the explanation of the algorithm was not so clear. In addition, there was a concern on the neutrality of the technology, that is, the degree of complexity should be the same when the algorithm is implemented with ASIC or DSP. Finally, WG1 decided to discuss further to specify the random pattern generation method [3]. In this document, we revised the previous algorithm to resolve the raised issues and clarify the algorithm.
In addition, we clarify the possible combinations of gated DPCCH operation mode as an option for UE and UTRAN, and the operation when the downlink only gating is used is described.

2. Combination of Gating Operation Mode

UTRAN and UE negotiate the combination of gating operation parameters when needed. The parameters required to be negotiated are gating rate, gating pattern, and direction as follows.

Gating Rate	1	1/3	1/5

Gating Pattern	Random	Regular

Direction	Downlink Only	Uplink and Downlink

If the gating transmission is disabled (i.e., gating rate = 1), then the regular gating pattern shall be used. In the case where gated DPCCH transmission is used only for the downlink, then UE shall transmit the DPCCH in every time slots, and UE shall:

- adjust the transmit power in response to the valid downlink TPC, where valid downlink TPC means the downlink TPC transmitted at the gated-on slots
- ignore any downlink TPC that are received during the gated off slot, and the downlink transmit power shall remain constant
- generate and transmit uplink TPC based on the downlink symbols if the time slot is associated with the downlink gate-on slot
- repeat the previous uplink TPC if the time slot is associated with the downlink gate-off slot

3. Random Gating Pattern Generation Method

If the gated DPCCH transmission is enabled with random gating pattern, the downlink and uplink gating pattern shall be determined based on the parameters in Table 1.

Table 1. Parameters for Random Gating Pattern

Parameter	Value
CFN	0, 1, …, 255 (8bits)
gating rate	1/3 or 1/5
number of gating group(N_G)	5, if gating rate is 1/3 3, if gating rate is 1/5
gating group size (S_G)	3, if gating rate is 1/3 5, if gating rate is 1/5
$A = (a_0, a_1, \cdots, a_{18})$	1011010011011101001 (19bits)

CFN is a frame counter ranged from 0 to 255. The number of gating group (N_G) represents the number of gating groups in a frame. Each gating group consists of S_G (gating group size) consecutive slots, which is the number of slots in a gating group.

Let i be the CFN of the frame $(i = 0,1,\cdots,255)$ and j be the jth gating group in a frame $(j = 0,1,\cdots,N_G - 1)$, respectively, then the allocated time slot, $s(i, j)$, shall be given by

$$s(i,j) = \begin{cases} (A_j \oplus C_i)_{10} \bmod (S_G - 1) + 1, & j = 0 \\ (A_j \oplus C_i)_{10} \bmod S_G, & j = 1,\cdots,N_G - 2 \\ S_G - 1, & j = N_G - 1 \end{cases}, \quad i = 0,1,\cdots,255$$

where $A_j = (a_j, a_{j+1}, \cdots, a_{j+15}), j = 0,1,\cdots N_G - 2$, is a 16bit sequence constructed from A in Table 1 and Figure 1, and $C_i = ((\mathrm{CFN})_2, (\mathrm{CFN})_2)$ is a 16bit sequence consists of repeated binary representation of CFN, where $(\bullet)_m$ represents the m-ary representation of the argument. Figure 1 shows the explanation of sequence A and A_j.

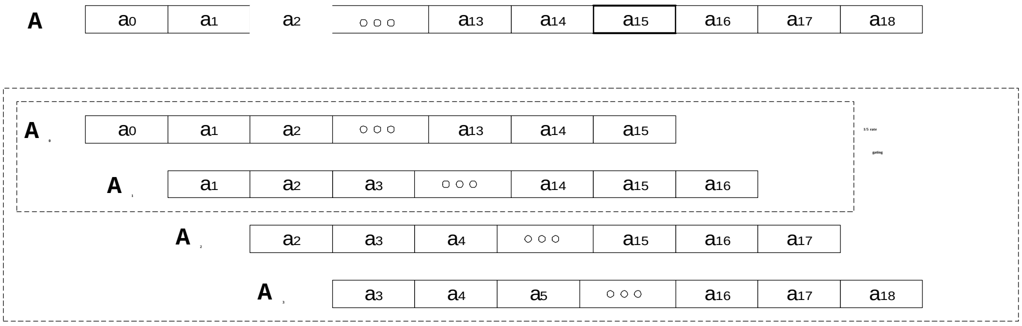

Figure 1. Sequence A and A_j

The range of $s(i, j)$ is {0,1,2} in case of 1/3 rate gating, and {0,1,2,3,4} in case of 1/5 rate gating except the first and last gating groups. It is worth noting that the first time slot of each frame shall never be allocated to $s(i, j)$ ($j = 0$ case), and the last time slot of each frame is always allocated to $s(i, j)$ ($j = N_G - 1$ case). Figure 2 explains the method of the proposed random pattern generation for uplink DPCCH gating.

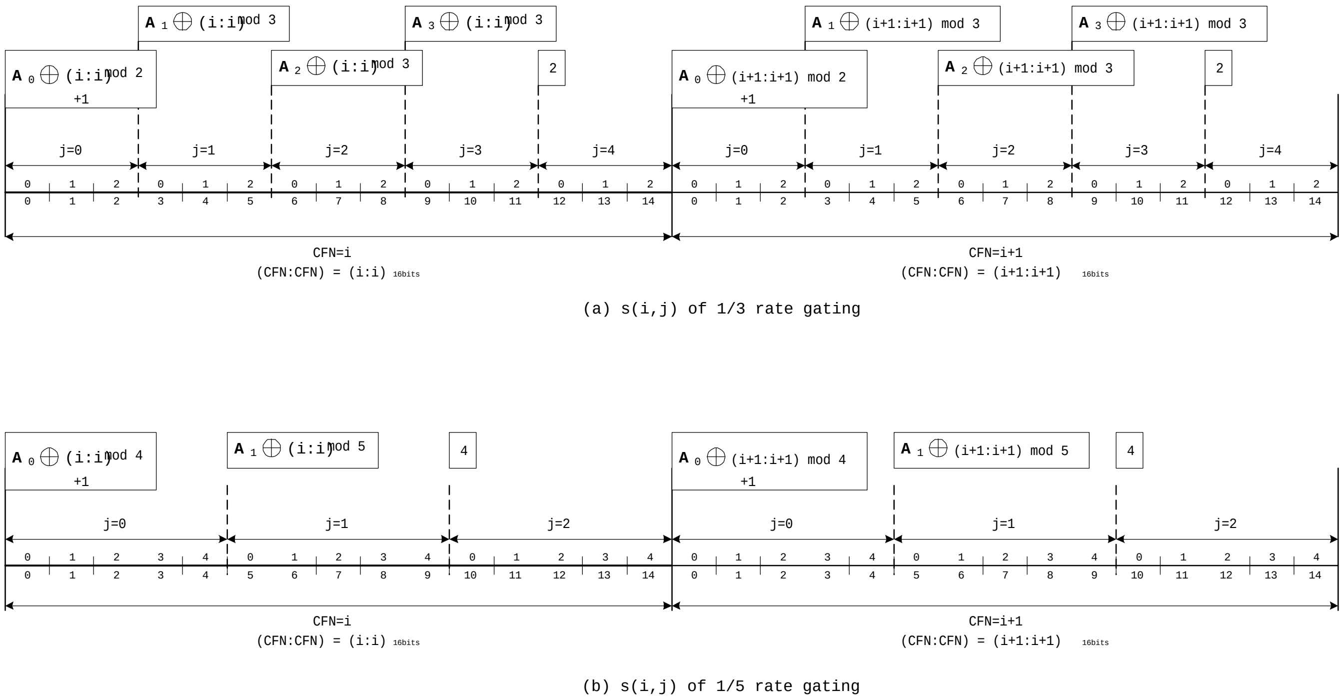

Figure 2. Calculation of $s(i, j)$: (a) 1/3 rate (b) 1/5 rate

The relative timings of the downlink and uplink DPCCH transmission with random gating pattern is depicted in Figure 3 for an example pattern. The gating pattern for the uplink slot in Figure 3 is (2, 0, 1, 0, 2) for 1/3 rate gating and (1, 2, 4) for 1/5 rate gating.

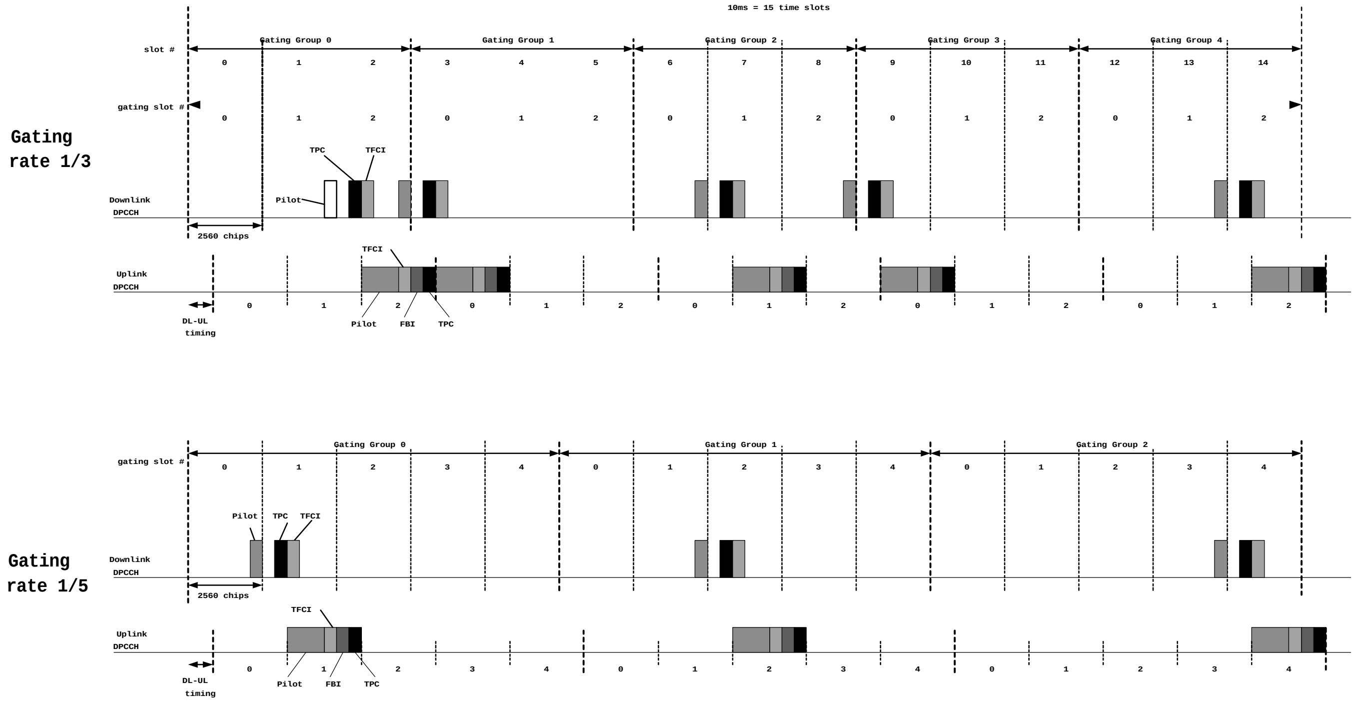

Figure 3. Uplink and Downlink DPCCH gating with random gating pattern

[Note: Downlink slot structure in Figure 3 is based on the figure agreed through e-mail discussion between WG1#8 and WG1#9 meetings.]

4. Power Spectral Density

The most important factor related to the EMC effect is the power spectral density of the gating pattern. In regular gating pattern, the periodic low frequency components are included which may result in some sound to the nearby hearing aid apparatus from UEs.. By randomizing the gating pattern, the power spectrum might be spread out over frequency ranges and the sound heard through the hearing aid apparatus becomes random-noise-like and hard to notice. Figure 4 shows the power spectral density of the proposed random gating pattern. In addition, the power spectral density of the regular gating pattern is also plotted to compare the spectral density.

(a) (b)

Figure 4. Power spectral density of (1/3 rate gating): (a) regular pattern (b) random pattern

From this figure, we can ascertain the fact the power spectrum becomes wide spread over frequency ranges and the peak power spectral density becomes much smaller than that of the regular gating patter. The reduction of the peak power spectral density of the proposed random gating from the regular gating is summarized in Table 2.

Table 2. Reduction of Peak Power Spectral Density from Regular Gating

	1/3 rate gating	1/5 rate gating
Reduction	11.7dB	8.5dB

5. Conclusion

The main advantages of the gated DPCCH transmission are increase of UE battery and increased link capacity. However, the regular gating pattern may be accompanied by the EMC effects to the hearing aid apparatus due to the periodic nature. In this document, we propose random gating pattern with which the periodic nature becomes random nature and consequently the EMC effects can be avoided.

6. References

[1] TSGR1#8(99)f43, "Reducing EMC problem in uplink DPCCH Gated mode," Mitsubishi, New York, 12-15 Oct. 1999.
[2] TSGR1#8(99)g54, "Revised Random Pattern for DPCCH Gated Transmission (Rev. of R1-99f80)," Samsung, New York, 12-15, Oct. 1999.
[3] TSGR1#8(99)h77, "Draft minutes for 3GPP RAN-TSG 8th WG1 meeting," New York, 12-15, Oct. 1999.

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